Evaluation of Current Planetary Boundary Layer Retrieval Capabilities from Space

Joseph A. Santanello, Jr.[1], Alexander J. Schaefer[2], John Blaisdell[3], and John Yorks[3]
[1]Hydrological Sciences Laboratory, NASA/GSFC; [2]University of North Carolina at Charlotte
[3]Mesoscale Atmospheric Processes Laboratory, NASA/GSFC

AIRS-based Temperature and Humidity Profiles vs. Radiosonde

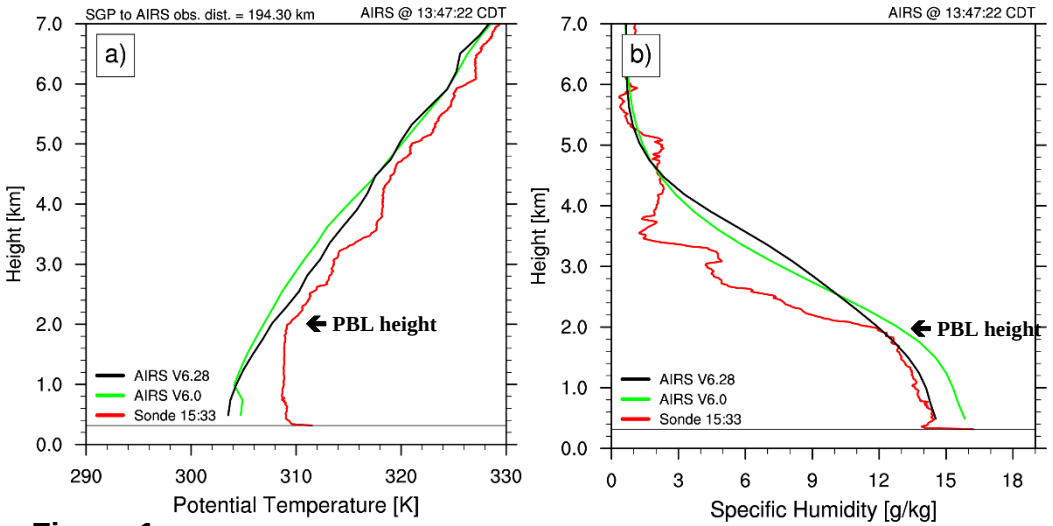

Figure 1

Properties of the planetary boundary layer (PBL), which are key to our understanding and prediction of the water cycle, can be monitored by NASA's satellite-borne CALIPSO (PBL height), CATS (PBL height), and AIRS (PBL temperature and humidity) instruments.

CALIPSO and CATS Backscatter Retrievals

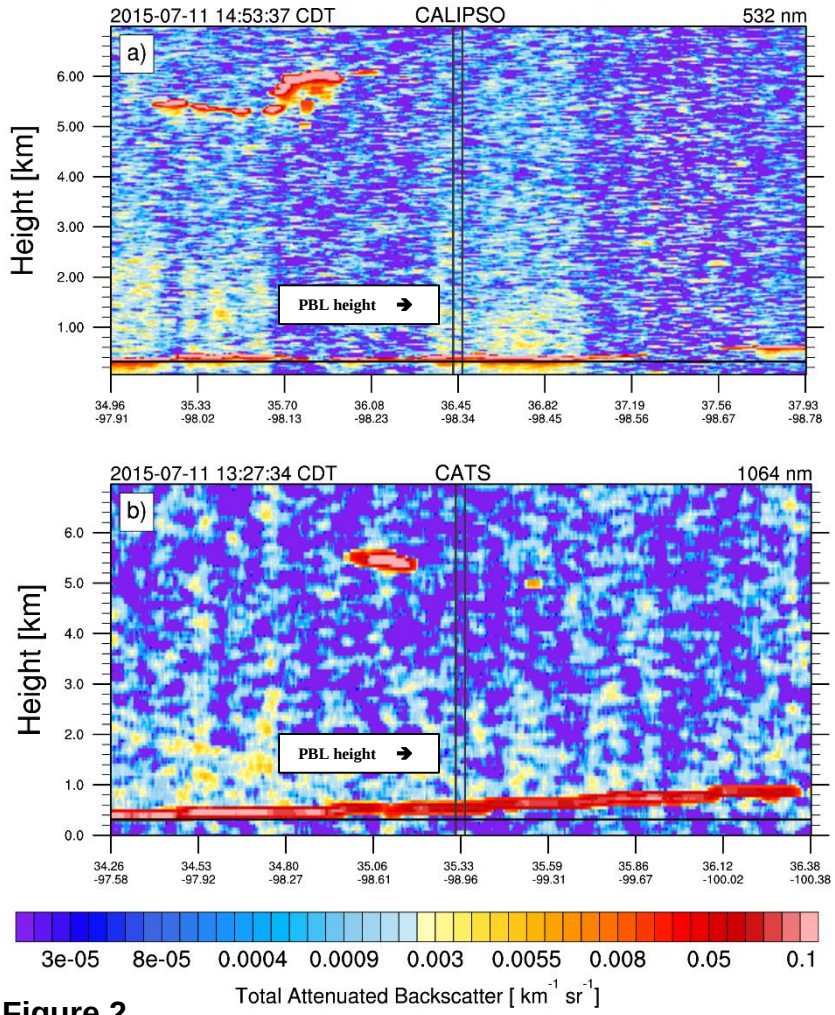

Figure 2

Name: Joseph A. Santanello, Jr.,Hydrological Sciences, NASA GSFC
E-mail: Joseph.A.Santanello@nasa.gov
Phone: 301-286-7450

References:

Santanello et al., 2015: **The Importance of Routine Planetary Boundary Layer Measurements over Land from Space**. NRC Decadal Survey 2017-2027, Request for Information #1. http://sites.nationalacademies.org/DEPS/ESAS2017/index.htm
Santanello et al., 2016: **The Boundary Layer Gap over Land and Importance of Improved Retrieval from Space.** NRC Decadal Survey 2017-2027, Request for Information #2. http://sites.nationalacademies.org/DEPS/ESAS2017/index.htm

Data Sources:

AIRS: The Atmospheric Infrared Sounder (AIRS) instrument aboard NASA's AQUA spacecraft provides Level 2 profile retrievals (V6.0) to the public. Version 6.28 was obtained from J. Susskind's sounding team, and includes improved land surface emissivity, lower tropospheric channel selection sensitivity, and humidity treatments. The nearest granule to the Southern Great Plains (SGP) site was selected (~200km away).
CALIPSO: Level 1B backscatter (532 nm) data was acquired from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite. A running average, 17 horizontal and 2 vertical bins, was used to smooth out excess noise in the horizontal transect shown, which covers approximately 300 km in length from SSE to NNW over the SGP domain.
CATS: Level 1B backscatter (1064 nm) data were obtained from the Cloud-Aerosol Transport System (CATS) instrument website. A running average, 27 horizontal and 3 vertical bins, was applied to smooth out excess noise in the horizontal transect shown, which covers approximately 300 km in length from SE to NW
In-situ: Hourly radiosondes were launched from the SGP facility in Lamont, OK as part of an IOP campaign (Co-I Santanello) in Summer 2015, as coordinated with CATS overpasses (J. Yorks) and hydrological regimes of interest.

Technical Description of Figures:

Figure 1: Mid-afternoon vertical profiles of **a)** potential temperature and **b)** specific humidity from AIRS V6.0, V6.28, and from the closest radiosonde launch at the SGP site in Lamont, OK on 5 July 2015. V6.0 and V6.28 fail to correctly identify PBL height (PBLh) with respect to potential temperature due to a lack of vertical resolution and inability to detect vertical gradients and the PBLh inversion layer. V6.28 indicates some overall improvement over V6.0 for correctly identifying the specific humidity profile in the lower troposphere, likely as a result of the modifications to the retrieval algorithm listed above.
Figure 2: Horizontal transect of total attenuated backscatter profiles from the **a)** CALIPSO and **b)** CATS lidar over the ARM-SGP domain on 11 July 2015 during the mid-afternoon. The black arrow indicates the radiosonde estimate of PBLh for the time nearest the instrument flyover. Yellow values show areas of higher aerosol concentrations and red/pink are areas indicative of clouds. The more consistent PBL depicted by CALIPSO also shows a sharp gradient from yellow to blue that indicates the PBLh. CATS depicts pockets of aerosols but lacks a distinct layer like CALIPSO due to reduced signal-to-noise ratios observed during daytime.

Scientific significance, societal relevance, and relationships to future missions: The PBL over land remains a significant gap in our water and energy cycle understanding from space. This work combines unique NASA satellite and model products to demonstrate the ability of current sensors (advanced IR sounding and lidar) to retrieve PBL properties and in turn their potential to be used globally to evaluate and improve weather and climate prediction models. While incremental progress has been made in recent AIRS retrieval versions, insufficient vertical resolution remains in terms of detecting PBL properties. Lidar shows promise in terms of detecting vertical gradients (and PBLh) in the lower troposphere, but daytime conditions over land remain a challenge due to noise, and their coverage is limited to ~2 week or longer return times.